**Omaha Public Power District**

# Fuel Cell Energy at the Henry Doorly Zoo

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Federal Utility Partnership Working Group

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# History of Fuel Cell Technology

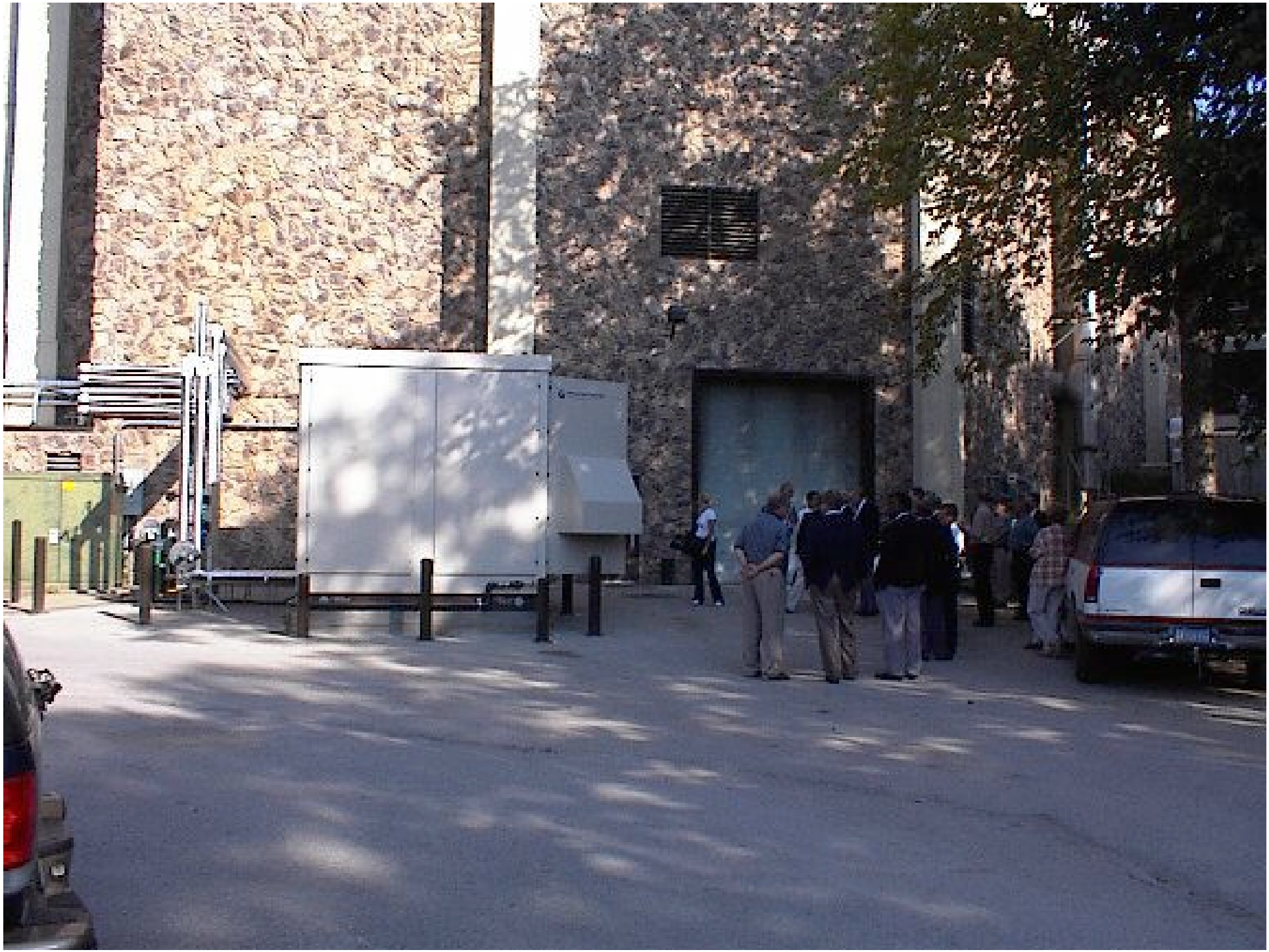
- First Fuel Cell developed in 1839 by Sir William Grove
- First practical use - space program in 1960's
- UTC Fuel Cells PC25 commercial units available since mid-1990's
- Over 200 units currently in operation worldwide

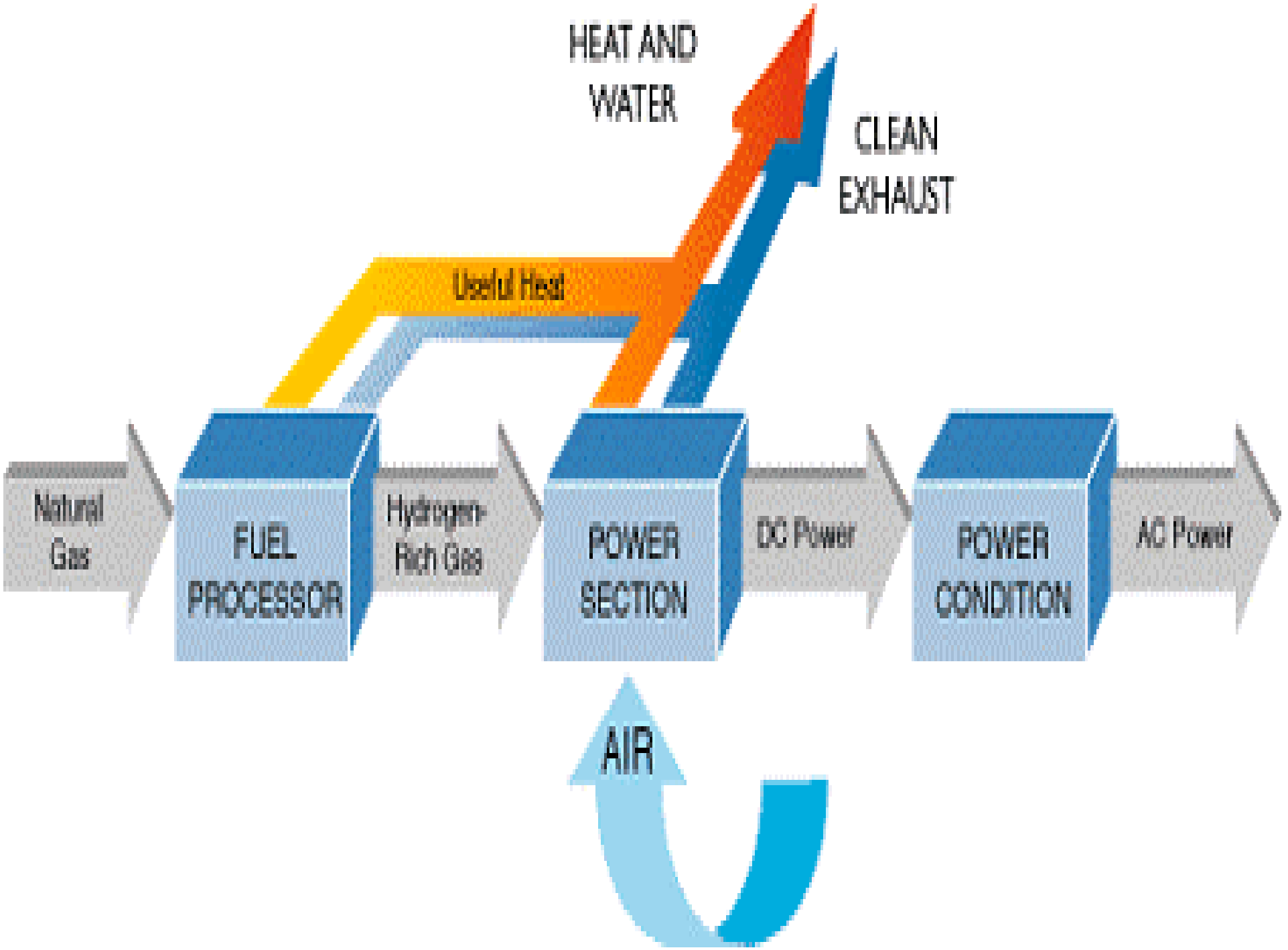
# Henry Doorly Zoo Project Summary

- Installed as a technology demonstration
- Model PC25C fuel cell commissioned on 8/8/01
- Supplied by UTC Fuel Cell - East Windsor, Connecticut
- Installed at Lied Jungle
- 200 kW  unit serves 50% of power needs of Lied Jungle
- Installation Complete - August, 2001

# Design Objectives

- Supply power to critical Jungle systems
- OPPD grid is backup power
- Low  temp heat used to temper cold water
- High temp heat used to supplement boilers




HEAT AND
WATER
CLEAN
EXHAUST
Useful Heat
Natural
Gas
FUEL
PROCESSOR
Hydrogen-
Rich Gas
POWER
SECTION
DC Power
POWER
CONDITION
AC Power
AIR

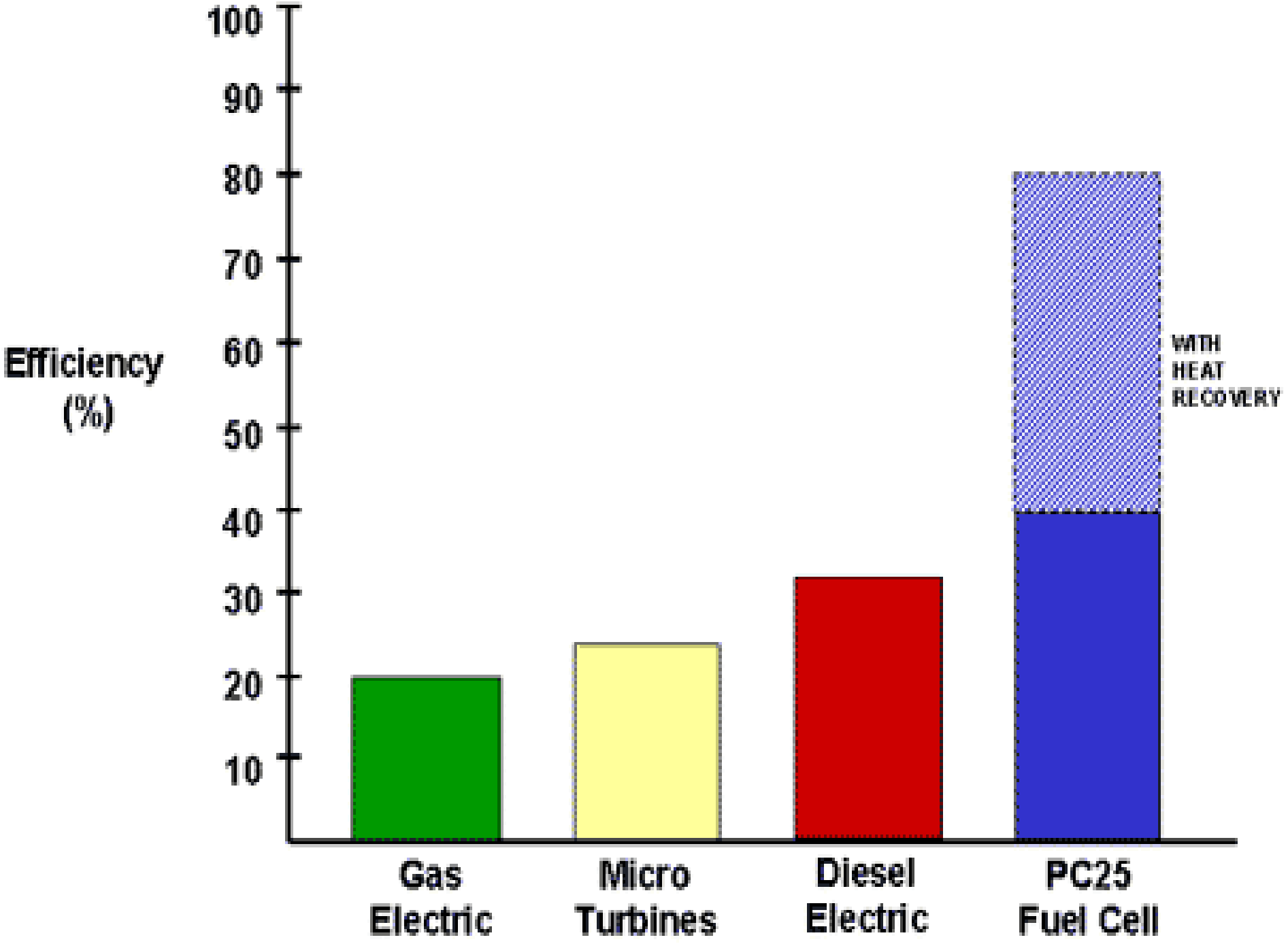
# How it works

# How it works

- Hydrogen is removed from NG
- Hydrogen protons pass through cell membrane
- Electrons pass around membrane creating DC circuit
- Oxygen combines with hydrogen protons to form water
- Fuel cell produces electricity, heat, and water

# Fuel Cell Advantages

- Minimal environmental impact
- High efficiency w/waste heat recovery
- Provides premium power and increased reliability


Efficiency
(%)
100
90
80
70
60
50
40
30
20
10
WITH
HEAT
RECOVERY
Gas
Electric
Micro
Turbines
Diesel
Electric
PC25
Fuel Cell

# Emissions and Sound

- 1 ppm Nitrogen Oxides (NOx)
- 5 ppm Carbon Monoxide (CO)
- Negligible Sulfur Oxides (SOx)
- Negligible particulates
- No smoke
- Noise - 62 decibels (dBA) at 30 feet

# Operating Data

| | |
|---|---|
| Peak Output | 200 kW @ 480v |
| Annual Generation | 1,314,000 kWh |
| Capacity Factor | 75% |
| Heat Rate | 9500 Btu/kWh |
| w/Waste Heat | 6000 Btu/kWh |
| Fuel Consumption | 12,483 MBtu/yr |
| Waste Heat | 4,599 MBtu/yr |

# Construction Costs

| | |
|---|---|
| Fuel Cell | $ 840,000 |
| Installation | $ 252,000 |
| HDR Engineering | $ 85,000 |
| Project Management | $ 36,000 |
| Financing | $ 16,000 |
| TOTAL Cost | $1,229,000 |

# Net Cost with DOE Grant

- **Total Costs** **$1,229,000**
- **DOE Grant** **($ 200,000)**
- **NET COST** **$1,029,000**
- **Cost per kW** **$5,145/kW**

# Annual Costs

- Carrying Costs $ 81,600 (5.5%, 20 yr)
- O&M $ 26,000
- Fuel $ 37,400 ($3/mmBtu)
- TOTAL COST $145,000
- Waste Heat ($14,000)
- NET COST $131,000

# Annual Energy Cost

- **Annual Cost** **$131,000**
- **Generation*** **1,314,000 kWh**
- **Busbar Cost**** **10 cents/kWh**

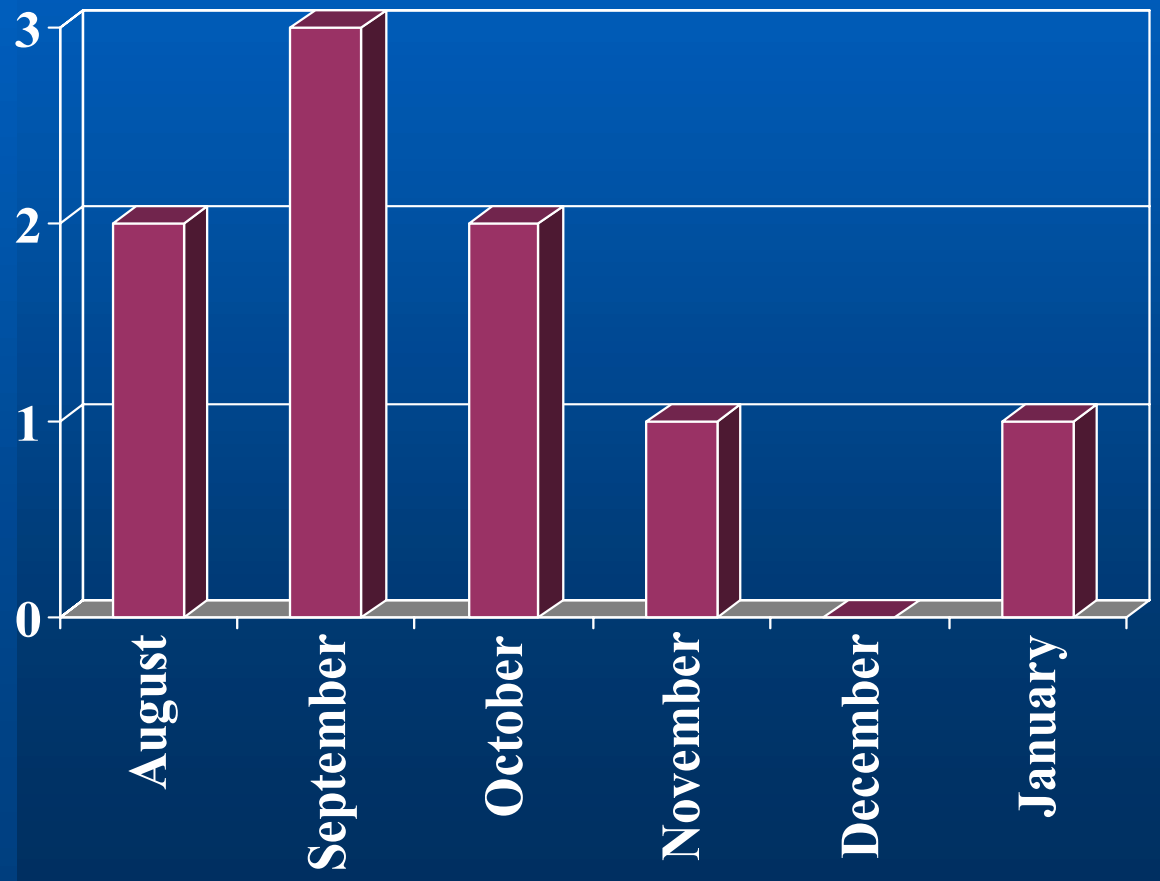
*** Based on 75% capacity factor**

**** Compares with oil-fired turbine**

# Rate Comparison

| | |
|---|---|
| • OPPD Average Rate | 5.5 c/kWh |
| • Green Rate | 4 - 6 c/kWh |
| • Premium Power | 0 - 1 c/kWh |
| • TOTAL | 9.5 - 12.5 c/kWh |
| • FUEL CELL | 10 c/kWh |

# Unit Trips



# Performance Statistics

8-8-01 and 1-31-02

- **Availability - 50 %**
- **Capacity factor - 47.9 %**
- **Electrical Efficiency - 30 %**
- **Overall Efficiency - 34 %**

# Other Issues

- N2 content of gas.  4% limit.  About 6-7% most time.
- Have to dispose of inferior gas if gas is scrubbed.
- Need steady load.  Follows 10kw/sec load variations well.  Up and down not well.
- Optimize thermal use in zoo.


CLEAN EMISSIONS
COMPUTER GRADE POWER
NEW TECHNOLOGY
FUEL CELL
Fuel Cell at the Zoo
New Technology at Work
Fuel Cell Facts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